

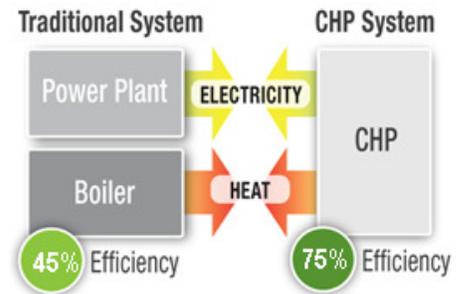
### What is combined heat and power (CHP)?

Combined heat and power (CHP) is an efficient and clean approach to generating electric power and useful thermal energy from a single fuel source. CHP is used either to replace or supplement conventional separate heat and power (SHP). Instead of purchasing electricity from the local utility and burning fuel in an on-site furnace or boiler to produce thermal energy, an industrial or commercial facility can use CHP to provide both energy services in one energy-efficient step.

### How Does CHP Work?

- Every CHP application involves the recovery of otherwise-wasted thermal energy to produce useful thermal energy or electricity. CHP can be configured either as a topping or bottoming cycle.
- In a typical topping cycle system, fuel is combusted in a prime mover such as a gas turbine or reciprocating engine to generate electricity. Energy normally lost in the prime mover's hot exhaust and cooling systems is instead recovered to provide heat for industrial processes (such as petroleum refining or food processing), hot water (e.g., for laundry or dishwashing), or for space heating, cooling, and dehumidification.
- In a bottoming cycle system, also referred to as "waste heat recovery," fuel is combusted to provide thermal input to a furnace or other industrial process and heat rejected from the process is then used for electricity production.

CHP Process Flow Diagram



Source: Oak Ridge National Laboratory, *Combined Heat and Power: Effective Energy Solutions for a Sustainable Future*, 2008.

### Why is CHP more efficient than conventional electricity generation?

CHP is a form of distributed generation, which is located at or near the energy-consuming facility, whereas conventional generation takes place in large centrally-located power plants. CHP's higher efficiency comes from recovering the heat normally lost in power generation or industrial processes to provide heating or cooling on site, or to generate additional electricity. CHP's inherent higher efficiency and elimination of transmission and distribution losses from the central power plant results in reduced primary energy use and lower greenhouse gas (GHG) emissions.

### Is CHP widely used in the United States?

- The existing 82 GW of CHP capacity at almost 3,600 industrial and commercial facilities represents approximately 8 percent of current U.S. generating capacity and over 12 percent of total electricity generated.
- CHP is used in every state, and is primarily found in areas with high concentrations of industrial and commercial activity, high electricity prices, and policies favorable to CHP.

### What kinds of facilities use CHP?

CHP can be utilized in a variety of applications that have significant electric and thermal loads. Eighty-eight percent of existing CHP capacity is found in industrial applications, providing electricity and steam to energy-intensive industries such as chemicals, paper, refining, food processing, and metals manufacturing. CHP in commercial and institutional applications is currently 12 percent of existing capacity, providing electricity, steam, and hot water to hospitals, schools, university campuses, hotels, nursing homes, office buildings and apartment complexes.

### What are the benefits of CHP for the energy user?

- CHP reduces energy costs for the user.
- CHP reduces the risk of electric grid disruptions and enhances energy reliability for the user. This is particularly useful for hospitals, research institutions, or industrial facilities where electric power outages are particularly disruptive and costly.
- CHP provides predictability in the face of uncertain electricity prices.

### What are the benefits of CHP for the United States?

- CHP reduces emissions of GHGs and other air pollutants by as much as 40 percent or more.
- CHP consumes essentially zero water resources in generating electricity (a typical coal fired power plant consumes 0.2 to 0.6 gallons of water per kWh<sup>1</sup>).
- CHP offers a low-cost approach to adding new electricity generation capacity.
- On-site electric generation reduces grid congestion and improves the reliability of the electricity distribution system.
- CHP defers the need for investments in new central generating plants and new transmission and distribution infrastructure, helping to minimize increases in electricity costs.
- CHP uses highly-skilled local labor and American technology.

### How do the benefits and costs of CHP compare to other clean energy technologies?

Category	10 MW CHP	10 MW Wind	10 MW Natural Gas Combined Cycle
Annual Capacity Factor	85%	34%	70%
Annual Electricity	74,446 MWh	29,784 MWh	61,320 MWh
Annual Useful Heat	103,417 MWh <sub>t</sub>	None	None
Footprint Required	6,000 sq ft	76,000 sq ft	N/A
Capital Cost	\$20 million	\$24.4 million	\$9.8 million
Cost of Power*	7.6 ¢/kWh	7.5 ¢/kWh	6.1 ¢/kWh
Annual Energy Savings	316,218 MMBtu	306,871 MMBtu	163,724 MMBtu
Annual CO <sub>2</sub> Savings	42,506 Tons	27,546 Tons	28,233 Tons
Annual NO <sub>x</sub> Savings	87.8 Tons	36.4 Tons	61.9 Tons

**Table Assumptions:** 10 MW Gas Turbine CHP-28% electric efficiency, 68% total efficiency, 15 PPM NO<sub>x</sub>; Electricity displaces National All Fossil Average Generation (eGRID 2010)-9,720 Btu/kWh, 1,745 lbs CO<sub>2</sub>/MWh, 2.3078 lbs NO<sub>x</sub>/MWh, 6% T&D loss; Thermal displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NO<sub>x</sub> emissions; NGCC NO<sub>x</sub> emissions = 9 ppm; DOE EIA Annual Energy Outlook 2011 assumptions for Capacity Factor, Capital cost, and O&M cost of 7 MW utility scale PV, 100 MW utility scale Wind (1.5 to 3 MW modules) and 540 MW NGCC; Capital charges based on: 7% interest, 30 year life for PV, Wind and NGCC, 9% interest, 20 year life for CHP; CHP and NGCC fuel price = \$6.00/MMBtu.

\*The cost of power for CHP is at the point of use; the cost of power for PV, wind and central station combined cycle is at the point of generation and would need to have transmission and distribution costs added to the totals in the table (2 to 4 ¢/kWh) to be comparable.

### What can CHP contribute in the future?

An additional 50 GW of capacity—equal to about half of current U.S. nuclear generation capacity—could be cost-effectively deployed by 2020 and would produce annual savings of \$77 billion.<sup>2</sup> The Department of Energy’s Clean Energy Application Centers and the EPA CHP Partnership offer information on policies that promote clean energy generation technologies such as CHP. See

<http://www.midwestcleanenergycenter.org/policy/> and <http://epa.gov/chp/state-policy/index.html>.

<sup>1</sup> EPRI, *Water & Sustainability: U.S. Water Consumption for Power Production – The Next Half Century*, 2002

<sup>2</sup> McKinsey & Company, *Unlocking Energy Efficiency in the U.S. Economy*, 2009.